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(54) **A PIPELINE TOOL**

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(73) Proprietor: **The Safer Plug Company Limited**
Grand Cayman, KY1-1108 (KY)

(72) Inventors:
- **EARLY, Ciaran**
  Dublin 6W (IE)
- **MURRAY, Gary**
  Dublin 16 (IE)
- **HONOUR, Raymond**
  Ramsgate
  Kent CT11 8AN (GB)

(74) Representative: **MacLachlan & Donaldson**
2b Clonskeagh Square
Clonskeagh Road
Dublin 14 (IE)

(56) References cited:
WO-A1-2005/028942
WO-A1-2005/061944
WO-A2-03/067134
US-A- 5 018 451

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Description

[0001] The present invention relates to a pipeline tool in particular to a robotic pipeline tool suitable for pushing or pulling other pipeline tools such as an autonomous isolation tool within a pipeline.

[0002] There is a frequent requirement to intervene in pipeline systems, risers, valves, or other pipeline appurtenances, in order to effect isolation activity. This is to enable, for example, repair of a pipe section or valve, to conduct a hydrostatic test against a new addition to a pipeline system or valve replacement, or alternatively to do remedial work. There could also be requirements to survey, to photograph, to review damage, to conduct Magnetic Flux Leakage, to Corroscan, to paint or to conduct any other pipeline intervention operation. Such operations require placement of a piece of specialist equipment at a precise location within a pipeline.

[0003] To date, the movement of tools into position within pipelines has been achieved using a fluid pigging medium selected from one or more of the following examples water, oil, condensate MEG (monoethylene glycol), air, nitrogen or the pipeline's own gas product.

[0004] Pigging of specialist equipment to location using pipeline gas is difficult, as the tool being pigged tends to intermittently stop and start depending on the tools pigging friction with the pipe wall, the weight of the tool and the differential pressure being used to propel the tool along the pipeline against the gas pressure already present in the pipe line. Precise positioning at the desired location can be difficult and often arbitrary. Current practice involves the use of techniques such as open throttling and flaring off of the down-stream pressure in order to spring the item to the desired location.

[0005] A particular problem associated with moving or pigging a tool to a desired location in a gas pipeline system using water is the possibility of water by-pass and consequently formation of hydrates. Hydrates can cause a blockage in a pipeline. Should hydrates form in a pipeline it is then necessary to insert a specialist piece of equipment or introduces a chemical agent into the pipeline to breakdown the blockage. Other problems include corrosion from the introduction of water which is detrimental to the overall integrity of the pipeline system, Other problems include backing strips at the field joint weld location in some pipelines, which makes pigging difficult.

[0006] Major gas pipeline transportation systems require regular planned double block and bleed isolation, in order to conduct servicing on the valve systems at their upstream or downstream terminals.

[0007] It is therefore an object of the present invention to provide a pipeline tool that will eliminate the requirement to introduce a pushing fluid and its associated hazards, and that this pipeline tool is suitable for use with other pipeline tools, in particular autonomous isolation tools that will overcome the problems associated with moving pipeline tools to a location within a pipeline.

[0008] Pipeline transportation systems worldwide, especially gas pipeline systems would benefit from having a pipeline tool that obviates or makes un-necessary the requirement to use fluid and eliminates the possibility of water ingress when conducting maintenance activities. Northwest European gas transportation pipeline systems include for example;

Ref	Name	Length	Diameter
1	Bacton to Zeebrugge UK Interconnector	233km	40 inch
2	Zeepipe Norway to Belgium	814km	40 inch
3	Balzand Interconnector	235km	36 inch
4	Europipe 1 Norway to Germany	660km	40 inch
5	Europipe 2 Norway to Germany	642km	42 inch
6	Norpipe	440km	36 inch
7	Franpipe Norway to France	840km	42 inch
8	Ormen Lange Norway to England	1166km	44 inch
9	SNIP Scotland to Northern Ireland	50km	24 inch
10	Eire Interconnector Scotland to Ireland	190km	24 inch
11	Eire Interconnector 2 Scotland to Ireland	194km	30 inch
12	Statpipe Norway to Germany	882km	28/36 in
13	FLAGGS to UK	448km	36 inch
14	Frigg St Fergus	2x360km	2x32 in

(continued)

Ref	Name	Length	Diameter
15	LOGGS to Theddlethorp	120km	36 inch
16	Miller to St Fergus	242km	30 inch
17	SAGE to St Fergus	325km	30 inch
18	SEAL to Bacton	463km	34 inch
19	West Shetland to UK	395km	20 inch
20	Fulmar to St Fergus	229km	30 inch

[0009] A tool according to the preamble of claim 1 is known from document WO-A-2005/061944.

[0010] Aspects of the present invention will become apparent from the ensuing description which is given by way of example only.

[0011] Accordingly, the present invention provides a pipeline tool as set out in the appended Claims 1 to 17.

[0012] The advantage of this tool is that it is self-propelled, thus it is moveable to an accurate location within a pipeline without the use of water, or a propelling medium thereby eliminating the requirement to introduce a pushing fluid and its associated hazards. In a further embodiment of the invention the pipeline tool is connectable to another pipeline tool for example, a pipeline isolation tool. Consequently the pipeline tool of the invention provides a means for moving or accurately locating another pipeline tool at a desired location within a pipeline.

[0013] The pipeline tool of the present invention is suitable for use in straight pipe. In use, a pipeline has a plurality of valves at the termination points of the pipeline in order to retain the contents of the pipeline. These valves require maintenance or replacing over time.

[0014] When the valves are repaired or replaced one or more isolation plugs are installed into the main pipeline in an autonomous intervention process. The pipeline tool of the present invention is particularly suitable for use in the straight sections of pipe positioned at pipeline termination points especially the sections of pipe associated with autonomous intervention into main pipeline transportation systems.

[0015] The applicant has a further invention relating to a pipeline tool that is suitable for positioning of autonomous isolation tools or other equipment in pipeline locations where bends, branching Y's, Tees or risers have to be negotiated before the equipment reaches the desired location. This further invention is the subject of another International Patent Application.

[0016] In a further aspect of the invention, the control unit of the pipeline tool is provided as a control pod which contains at least one microprocessor. In a preferred embodiment of the invention there are at least two microprocessors. In a further aspect of the invention the microprocessors are programmed with an embedded software program. In this way the control unit is programmed to control the movement of the pipeline tool through a pipeline transportation system. Conveniently this enables the pipeline tool of the invention to move horizontally, up or down inclines, and to move a load vertically up or down a straight pipeline section.

[0017] In a further embodiment of the invention the control unit further comprises a communications module which enables the pipeline tool to utilize ELF communications.

[0018] The advantage of this is that the control unit of the pipeline tool of the invention is completely autonomous.

[0019] According to the invention the pipeline tool comprises a primary and a backup hydraulic system. The primary and backup hydraulic system are completely independent from each other. Conveniently, the hydraulic system comprises at least one hydraulic piston or ram coupled to a plurality of fluid pipes and hydraulic fluid which flows around the hydraulic circuit to effect movement of the pipeline tool.

[0020] In a further aspect of the invention each of the primary and backup hydraulic systems comprise a plurality of hydraulic pistons or rams, wherein at least one piston or ram is an axial piston or ram and at least one piston or ram is a longitudinal piston or ram. It is to be understood that the terms piston or ram are used interchangeably throughout the specification. Conveniently the axial ram and longitudinal rams are arranged such that they are perpendicular to one another.

[0021] In a further aspect of the invention each hydraulic system comprises at least nine rams wherein at least eight rams are axial rams and at least one ram is a longitudinal ram.

[0022] The longitudinal rams of each hydraulic system are arranged such that they are parallel to each other. The hydraulic ram of the backup hydraulic system remains recessed when not in use. The advantage of this is that it avoids interfering with the operation of the primary hydraulic system. In order to achieve this purpose, the piston or ram of the backup hydraulic system is slightly shorter than the piston or ram of the primary hydraulic system.

[0023] In a further aspect of the invention each of the axial hydraulic rams are arranged such that standard opposing

forces principles enable each of the hydraulic rams to engage with the internal surface of the pipeline wall such that the pipeline tool remains in position within the pipeline regardless of the inclination of the pipeline or whether or not the surface of the pipeline is coated.

[0024] In a further aspect of the invention each of the axial hydraulic rams are provided with a pipeline engaging means. In a preferred embodiment of the invention the pipeline engaging means is a coated compression pad. This provides the compression pad with a surface which is tactile which promotes adhesion to the internal pipe wall surface. In one embodiment of the invention the compression pad is a rubber coated compression pad. In a further embodiment of the invention the compression pad is a threaded compression pad. It is understood that any suitable coating which is known to a person skilled in the art can be used.

[0025] In the preferred embodiment of the invention the control system of the pipeline tool monitors the operation of the hydraulic system. Conveniently monitoring of the hydraulic system is achieved by using one or more various types of sensors such as pressure sensors and proximity sensors. In use the sensors monitor various pressure levels on the pipeline tool of the invention. For example, the pressure levels between the pipeline engaging means and the interior surface of the pipeline. A further example includes the pressure within the pipeline as detected by the first and second parts of the pipeline tool. It is to be understood that the examples given are not limiting and that a person skilled in the art can place sensors within the pipeline tool of the invention at any desired location.

[0026] Preferably each of the sensors is provided with transmitters and receivers to enable transmission and receipt of information to and from the central processing unit. Conveniently the central processing unit is programmed to detect whether or not the pressure levels detected by the sensors fall within predetermined parameters. In the event that the primary hydraulic unit fails, the central processing unit is able to switch to the backup hydraulic system.

[0027] In a further aspect of the invention the means for operating the hydraulic system of the pipeline tool comprises a pump for operating the rams and/or pistons, means for operating the pump, a plurality of fluid pipelines positioned between the pump and the hydraulic rams. The hydraulic system also comprises an accumulator positioned in parallel with the pump.

[0028] In a further aspect of the invention the hydraulic system of the pipeline tool is provided with one or more check valves and/or controllers which control the flow of hydraulic fluid around the hydraulic circuit to control the movement of the pipeline engaging means and the first and second parts such that the pipeline tool propels in a controlled manner, a pipeline isolation tool along the inside of a pipeline.

[0029] In a further aspect of the invention the valves of the hydraulic system are arranged in such a way to achieve a triple redundancy fail safe unset system.

[0030] In a further aspect of the invention the hydraulic system is an engine driven system.

[0031] In one embodiment of the invention the pipeline tool is fully retractable from within a pipeline.

[0032] In a further aspect of the invention the pipeline tool has a sleep mode which is operable when the propulsion means are not in use. Conveniently when the pipeline tool of the invention is in sleep mode, it is retractable and movable to a distant location within a pipeline using pigging means. In use, the pipeline tool of the invention is coupled to a further pipeline tool such as an isolation plug, the pipeline tool of the invention is launched down the pipeline in sleep mode, once the pipeline tool has been moved the required distance, the pipeline tool is activated thus exiting sleep mode, the pipeline tool is then remotely operable to position the load to a precise location within the pipeline. In a further embodiment of the invention the pipeline tool of the invention is fitted with pigging disks or coupled to a chaser pig. This ensure that the pipeline tool of the invention can be pigged back to the start point.

[0033] In a further aspect of the invention the pipeline tool is movable to a location by deploying the pipeline tool from a launcher barrel. Conveniently the pipeline tool can also be recovered into a launcher or receiver barrel. In practice the size of the launcher or receiver barrel is irrelevant as a cartridge insert can be used to modify the sizing to the appropriate or desired size for the pipeline tool of the invention

[0034] In a further embodiment the pipeline tool of the invention is able to enter the pipeline at a launcher or receiver and travel along the pipeline system pulling or pushing a load such as a pipeline isolation tool. Conveniently the orientation of the pipeline or the direction of travel of the pipeline tool of the invention within the pipeline is irrelevant. For example, the pipe within which the pipeline tool of the invention will travel can be horizontal, vertical or angled pipe wherein it is understood that horizontal is parallel to the x-axis, vertical is at right angles to the x-axis and angled is at any angle between an horizontal and vertical orientation. Furthermore it is to be understood that the pipeline tool of the invention can climb or descend whilst carrying or supporting a load within a vertical or angled pipe.

[0035] The pipeline tool of the invention is able to position the load with extreme accuracy without the use of a fluid or an external propelling medium.

[0036] The pipeline tool of the invention is further provided with a coupling mechanism which enables the pipeline tool to connect to a pipeline isolation tool or other technical equipment. In one embodiment of the invention the coupling mechanism comprises a double articulating ball and socket joint, a flexing spring joint, or a double acting universal joint.

[0037] It is to be understood that the pipeline tool of the present invention is suitable to support any other internal pipeline tool required within the industry. An example of other tools include a magnetic flux leakage train, a camera tool,

a radiography tool, a hydrate buster, a paint application tool, or as a pulling pipeline tool for introducing fibre optic cables into old pipelines, or as an extraction tool without requirement to pig or flood a pipeline. A further advantage of the present invention is that in use it eliminates the requirement to flood, to dewater and then to vacuum dry or recondition the pipeline.

[0038] According to a further aspect of the invention the pipeline tool is coupled to a wheeled isolation tool comprising;

a housing having gripping and sealing members encircling the housing in communication with a hydraulic system;
a control unit in communication with one or more sensors and an actuator positioned within the housing;
the gripping and sealing members being movable between an unset position in which the gripping and sealing members are in an unexpanded configuration and a set position in which the gripping and sealing members are in an expanded configuration whereby the control unit operates an actuator to move an hydraulic piston within the hydraulic system such that the gripping and sealing members are moved between an unset position and a set position.

[0039] In a further embodiment of the invention the pipeline isolation tool comprises a mechanical isolation tool. Conveniently the mechanical isolation tool can be located at either end of the pipeline tool of the invention.

[0040] Conveniently the isolation tool and pipeline tool of the invention operate in an autonomous environment without either an umbilical or tether attached to the housing of the invention.

[0041] The invention will hereinafter be more particularly described with reference to the accompanying drawings which illustrate by way of example only, two embodiments of the pipeline tool of the invention.

[0042] In the drawings;

Figure 1A is a perspective view of the pipeline tool of the invention;

Figure 1B and 1C are perspective and side views of the pipeline tool coupled to two pipeline isolation tools within a cut away pipeline;

Figure 2 is a side view of the pipeline tool of the invention;

Figure 2A is an end view of the pipeline tool of Figure 2;

Figure 2B is a side sectional view of the pipeline tool of Figure 2;

Figure 2C is an end view of the pipeline tool of the invention;

Figure 2D is a side view of the pipeline tool of Figure 2 with system A longitudinal piston in an extended state;

Figure 2E is a side sectional view of the pipeline tool of Figure 2D

Figure 2F is a second end view of the pipeline tool of the Figure 2 wherein the pipeline tool has been rotated through 90° relative to Figure 2A;

Figure 2G is a side view of the pipeline tool of Figure 2F with system A longitudinal piston in an extended state;

Figure 3 is an end view of the pipeline tool of Figure 1 within a pipeline showing the A set of pipeline engaging means engaging with the inner surface of the pipeline wall;

Figure 3A is a section through the axial ram system showing Axial A rams engaging the pipe wall;

Figure 3B is a section through the same axial ram system showing Axial B rams engaging the pipe wall;

Figure 3C is a section showing the latching receivers for longitudinal pistons and the spring receptacles for unlatching the receivers;

Figure 4 is a schematic diagram of the hydraulic circuits for System A and B of the pipeline tool of the invention;

Figure 4A is a schematic diagram of the hydraulic circuit of System A; and

Figure 5 is a flow diagram outlining the functionality of the Central Processing Unit of the pipeline tool of the invention.

[0043] Referring initially to Figures 1 to 3, there is shown a pipeline tool 100 of the invention.

[0044] Pipeline tool 100 comprises a control pod 130 which houses a pair of embedded microprocessors (not shown) and two hydraulic systems, hereinafter referred to as normal hydraulic system A and standby hydraulic system B. The components contained within the control pod 130 are housed in a one atmosphere (1 ata) pressurised housing. Pipeline 100 of the invention also comprises two longitudinal rams 160a and 160b together with a plurality of axial rams 140A, 140B, 150A and 150B. A plurality of wheels 120 are provided at opposing ends of the pipeline tool 100 in a circular arrangement. The spring loaded wheels 120 function to hold the pipeline tool 100 in the centre of the pipeline thereby preventing the body of the pipeline tool 100 which houses the control pod 130 from coming into contact with the surfaces of the internal wall of the pipeline as shown in Figure 1 B and 1C.

[0045] The pipeline tool 100 is provided with coupling means 170 which enables the pipeline tool 100 of the invention to couple to other items such as a pig train. Pipeline tool 100 can push or pull its load in either direction within the pipeline 172. In the example shown, pipeline tool 100 is coupled to a double module isolating plug 174. The double module isolating plug 174 is also provided with a number of circular wheel arrangements 120 to assist in movement of the pig train through the pipeline 172. The provision of the wheel arrangements 120 ensures that the pig train moves easily whilst being pushed or pulled through the pipeline 172, particularly given that the overall diameter of the double module isolating plug 174 is larger than that of the pipeline tool 100 of the invention. Coupling means 170 is in the form of an articulating double ball joint arrangement, wherein a ball connection is coupled to the socket 170A of the pipeline tool 100 as shown in Figures 1 B and 1C. The load coupled to the pipeline tool could also be, for example, any one of a single or triple module isolating plug, an intelligent pig, a gauge pig, a hydrate blaster or an internal paint coating tool or any other device. Although not shown, it is to be understood that the pipeline tool 100 is also provided with a coupling means 170 at the opposing end of the pipeline tool 100.

[0046] Either normal hydraulic system A or standby hydraulic system B is operated to move pipeline tool 100 through the pipeline 172. The main operational hydraulic system is normal hydraulic system A. In the event of failure of hydraulic system A, hydraulic system B becomes the main operational hydraulic system to effect movement of the pipeline tool 100. The pipeline tool 100 can achieve this functionality even when the pipeline is in a fully vertical orientation, regardless of whether or not the internal wall of the pipeline is coated with a material having flow enhancing properties.

[0047] The embedded microprocessors control the engine of the pipeline tool 100 which in turn drives the hydraulic ram systems A or B.

[0048] Normal hydraulic system A and standby hydraulic system B each comprise eight segmented axial rams which are configured to provide maximum grip against the pipeline wall. The axial rams of hydraulic system A are divided such that four axial rams 140a are located at the first end of the pipeline tool 100 and four axial rams 150a are located at the second end of the pipeline tool 100. The axial rams of hydraulic system B are also divided such that four axial rams 140b are located at the first end of the pipeline tool 100 and four axial rams 150b are located at the second of the pipeline tool 100. For the purposes of clarity the axial rams located at the first end of the pipeline tool are indicated collectively by reference numeral 140 and those at the second end of the pipeline tool are collectively indicated by reference numeral 150. In use, normal hydraulic system A drives the axial rams 140A and 150A and longitudinal ram 160A. Standby hydraulic system B drives the axial rams 140B and 150B and longitudinal ram 160B.

[0049] Referring to all of the figures and in particular, Figure 5, The microprocessors are nominated to respective sides of the pipeline tool 100 whereby side A of the control pod 130 corresponds to the first microprocessor which is in communication with normal hydraulic system A and side B of the control pod 130 corresponds to the second microprocessor which is in communication with standby hydraulic system B. The microprocessor at side A of the control pod 130 has priority until point of failure of side A. Failure of side A is subject to a set of system self diagnostics whereby the central processing unit 132 of the system diagnoses the status of various sensors 232, 234, 236, 238 and determines whether or not side A is operating within predetermined parameters. In the event that side A is operating outside the predetermined parameters then side A fails and side B takes control. The central processing unit 132 is provided with a self diagnostic system for the pipeline tool 100. A set of parameters or boundaries are provided which enable the central processing unit to determine when it is necessary and appropriate to allow side B to take control as determined in the resulting output 136.

[0050] Each of hydraulic ram systems A and B are further provided with a longitudinal ram 160a and 160b respectively. Each longitudinal ram 160 is positioned perpendicular to the segmented axial rams 140 and 150 as shown in Figure 2B.

[0051] The axial rams 140a of System A at the first and second ends of the pipeline tool 100 are arranged in a circular ring arrangement such that the angle between each consecutive axial ram of System A in the ring arrangement is approximately 90°. The axial rams 140b of System B are Interspaced between the axial rams 140a of System A such that the axial rams 140b of System B at the first and second ends of the pipeline tool 100 are also arranged in a circular ring arrangement whereby angle between each consecutive axial ram of System B in the ring arrangement is approximately 90°. Thus collectively the axial rams 140 and 150 of Systems A and B at the first and second ends of the pipeline tool 100 are arranged in the circular ring arrangement such that the angle between each consecutive axial ram in the ring arrangement is approximately 45°.

[0052] Each of the axial rams 140 and 150 are provided with rubber soled compression segment pads (Gekos) 142 positioned substantially perpendicularly to the axial rams 140 and 150 respectively (Fig 2). The gekos 142 follow the natural contour of the interior surface of the pipeline wall, such that the profile of each geko matches the interior curvature of the inner surface of the pipeline wall. The gekos 142 are each threaded to achieve the maximum grip possible.

[0053] Pipeline tool 100 moves upwards and downwards within a pipeline 30 as desired by means of the hydraulic systems A and B.

[0054] Referring specifically to Figures 3, 3A, 3B, 4 and 4A, each of the eight compression segment pads 142 at the extremity of axial rams 140a and 140b respectively are manipulated into the required position by separate hydraulically driven pistons 240 and 244 (Figure 4). Both hydraulic circuits for primary hydraulic system A and backup hydraulic system B are shown in Figure 4. In use, only the axial ram sets of System A or axial ram sets of System B at the first and second ends of the pipeline tool may function at any one time. For clarity the operation of primary hydraulic system A will be described with reference to Figure 4A. It is to be understood that backup hydraulic system B operates in a similar manner. Once the pistons have travelled the desired/required distance as determined by the piston 240A, 244A the respective segment pads 140A and 150A engage and lock onto the pipe wall 172 by hydraulic compression means as appropriate. For example as shown in Figure 3, the axial rams 140a of System A are locked onto the pipe wall 172 whilst the axial rams 140b of System B are in a retracted position. It is understood that the axial rams 150A and 150B of Systems A and B at the second end of the pipeline tool 100 behave in a similar manner.

[0055] The pressure exerted by the axial compression pads 142 on the inner surface of the pipeline wall 172 are carefully calculated, to ensure sufficient compression is exerted on the pipeline wall whilst ensuring that the pressure exerted stays within allowable pipe hoop stress values. Furthermore, when pipelines are internally painted with a flow enhancing finish, it makes it extremely difficult for anything to cling to the wall, nonetheless the compression pads 142 use standard opposing forces principles to overcome the problems associated with coated finishes.

[0056] The hydraulic ram systems A and B are configured to allow full redundancy for each ram system A and B and to allow either ram system A or B to drive the operation. Although not shown, each hydraulic engine of system A and system B also has separate pumps, gearboxes, motors, accumulators, system pressure vessels A and B, separate sensor system A and B for all hydraulic rams and pads, separate sensor systems A and B for orientation and attitude, separate command systems A and B, separate control systems A and B, separate sequencer systems A and B, separate battery systems A and B, separate power train systems A and B, full triple redundancy unset systems A and B, and separate ELF through pipe wall communications systems A and B.

[0057] Referring to Figure 4A, each of the independent rams 140A and 150A within hydraulic system A plus the ninth longitudinal ram 160A and the hydraulic system B unlatch mechanism, are driven by hydraulic pump 200A. Accumulator 202A is a pressurised reservoir which feeds oil into hydraulic pump 200A. Hydraulic pump 200A is driven by a motor 203A and gearbox 204A. For ease of reference each grouping of four axial A rams 140A and 150A correspond to axial hydraulic circuits 240A and 244A respectively. The ninth longitudinal ram 160A is marked as hydraulic circuit 242A. Fluid line 220A from hydraulic pump 200A feeds into hydraulic pistons 240A, 242A, and 244A through check valves 216A, valve controllers 210A, 212A and 214A and pressure transmitters 218A respectively.

[0058] Each of the rams 140A and 140B on the hydraulic systems A and B are fitted with a return spring 260A as shown in Figure 3A. The axial rams have a reciprocating linear movement which is controlled by the hydraulic circuit and spring 260A. Each axial hydraulic system 240A and 244A has a controller in the form of a lock out pressure valve 210A and 214A respectively. Such a pressure valve 210A and 214A, allows each axial ram 140A or 150A to move into an extended position whilst preventing the axial rams 140A or 150A from exerting too much pressure or imparting excessive hoop stress into the pipe wall.

[0059] In use, as the axial rams 140A and 150A are moved outwards by hydraulic rams 240A and 244A towards the inner surface of the pipeline wall, springs 260A are compressed. When hydraulic fluid is released by the controllers 210A and 214A, the compressed springs 260A recover their memory drawing the axial rams 140A and 150A away from the pipeline wall. The controllers 210A and 214A are indexed to a certain point which ensures that the axial compression rams 140A and 150A do not exert excessive pressure onto the pipe wall.

[0060] Both longitudinal ram systems 160A and 160B cannot operate simultaneously. The longitudinal rams 160A and 160B are fitted with spring loaded latching mechanisms. The energy to compress the spring to unlatch and release the longitudinal rams 160A and 160B in use, can only be initiated by hydraulic pressure. The hydraulic pressure to conduct this function on the B latching spring, comes from the primary hydraulic system A. The hydraulic pressure to conduct this function on the A latching spring comes from the B system. This ensures the secondary B longitudinal ram system is engaged and fully latched, before the A longitudinal ram system unlatching system is hydraulically activated, unlatched and released, thus allowing longitudinal ram 160A to be relocated in its receiver.

[0061] Valve 310A controls the operation of the spring loaded latching mechanism for 160B at 246B however 246B is physically located within the A side hydraulic system circuit.

[0062] Valve 310B (located within the B hydraulic system) controls the operation of the spring loaded latching mechanism for 160A at 246A , which is located within the B side hydraulic system circuit.

[0063] Each hydraulic circuit of the invention (side A and side B) is also provided with a triple redundancy fail safe unset system which ensures that the pipeline tool of the invention can be decoupled from engagement with the pipeline wall, and returned to the pipeline start point. The triple redundancy fail safe unset system comprises an independent primary, secondary, and tertiary unset system.

[0064] The primary unset system is a normal independent unset system which is operated using extremely low frequency (ELF) communications to move Valves 210A and 212A and 214A into an open position to unload the hydraulic fluid back to the accumulator 202A and thereby unlock the ram systems.

[0065] The secondary unset system comprises a hyberbaric or hydrostatic upset unset system whereby a pre-set integrated detenting pressure release valve 320A detects a hyperbaric spike. The pressure build up, when it reaches a certain value, causes a piston to move which drives a shuttle within the detenting valve 330A forward causing the integrated detenting valve to deflect and latch, thereby releasing the pressure and fluid from the circuit back to accumulator 202A.

[0066] The tertiary unset system comprises a timed decay unset system, whereby valve 300a is triggered to depressurize the circuit once a predetermined measure has been reached, for example a 10 day countdown.

[0067] Further redundancy can be added to System A and System B as required

[0068] The ninth ram 160A of primary hydraulic system A and 160B of backup hydraulic system B is longitudinal, and is located in the central line of the control pod, and is the motive force for driving the pipeline tool 100 up or down the pipeline. Ram 160A is referred to as 'middle' for the purposes of the sequencer process table below. The set of axial compression segment pads fitted to control pod 130 and known as 150 (meaning either system A or system B) are referred to as bottom for the purposes of the sequencer process table below.

[0069] The second set of axial compression segment pads 140 (meaning either system A or system B) are referred to as top for the purposes of the sequencer process table below. Control of movement of the pipeline tool 100 up or down the pipeline is managed by use of a sequencer process. An example of how the logic works is presented in the sequencer process table below. Movement of the pipeline tool 100 will now be described with reference to the Sequenser Process Table below;

Sequenser Process Table

Step	Bottom	Middle	Top	Remarks
1	**Extended** Axial compression segment pads 150 are extended and engage with the inner surface of the pipeline wall.	**Retracted** Ninth ram 160 is retracted.	**Extended** Axial compression segment pads 140 are extended and engage with the inner surface of the pipeline wall.	No movement
CHECK CONDITION				
2	**Extended** Axial compression segment pads 150 are extended and engage with the inner surface of the pipeline wall.	**Retracted** Ninth ram 160 is retracted	**Retracting** Axial compression segment pads 140 are disengaging with the inner surface of the pipeline wall.	**Moving** Retracting Top pads 140 move away from pipe wall. Pipeline tool is held on by bottom pads 150.
3	**Extended** Axial compression segment pads 150 remain extended and engaged with the inner surface of the pipeline wall.	**Extending** Ninth ram 160 is extending	**Retracted** Axial compression segment pads 140 remain retracted.	**Moving** Extending main cylinder to push rapid set isolation tool up pipe on ninth ram 160. Pipeline tool is locked on by bottom pads 150.
4	**Extended** Axial compression segment pads 150 remain extended and engage with the inner surface of the pipeline wall.	**Extended** Ninth ram 160 is extended.	**Extending** Axial compression segment pads 140 are extended and engage with the inner surface of the pipeline wall.	**Moving** Top pads 140 back onto pipe wall in new higher position. Pipeline tool is locked on with top 140 and bottom 150 pads
CHECK CONDITION				
5	**Retracting**	**Extended**	**Extended**	**Moving**

(continued)

CHECK CONDITION				
	Axial compression segment pads 150 are disengaging with the inner surface of the pipeline wall.	Ninth ram 160 is extended	Axial compression segment pads 140 remain extended and engaged with the inner surface of the pipeline wall.	Bottom pads 150 are lifted off pipe wall Pipeline tool is locked on by top pads 140
6	**Retracted**	**Retracting**	**Extended**	**Moving**
	Axial compression segment pads 150 remain retracted	Ninth ram 160 is retracting	Axial compression segment pads 140 remain extended and engaged with the inner surface of the pipeline wall.	Main longitudinal ram is used to pull pipeline tool up the pipeline to next step. Pipeline tool is locked on by top pads 140
7	**Extending** Axial compression segment pads 150 are extended and engage with the inner surface of the pipeline wall.	**Retracted** Ninth ram 160 is retracted	**Extended** Axial compression segment pads 140 remain extended and engaged with the inner surface of the pipeline wall.	**Moving** Bottom pads 150 are extended back onto pipe wall at new higher position. Pipeline tool is locked on with top 140 and bottom 150 pads
CHECK CONDITION				
Back To Step 1 again				
1	**Extended** Axial compression segment pads 150 are extended and engage with the inner surface of the pipeline wall.	**Retracted** Ninth ram 160 is retracted.	**Extended** Axial compression segment pads 140 are extended and engage with the inner surface of the pipeline wall.	No movement Pipeline tool is locked on all 9 hydraulic rams 140 and150 and 160 Ready to start next full sequence

[0070] During normal movement within a pipeline four degrees of freedom, up, down, left and right are used to leverage the axial rams against the pipeline wall 172 to grip the pipe wall. Once the pipeline tool 100 has gripped the pipeline wall 172, the longitudinal ram is extended which has the effect of moving the pipeline tool 100 up or down the pipeline thereby effecting movement of the pipeline tool 100.

[0071] Each of the axial rams at the first and second ends provides a gripping force whilst the longitudinal ram 160 pushes the propulsion tool 100 forward or backwards.

[0072] Although not shown an isotope can be mounted at some known radial point on the pipeline tool 100 to provide positioning information to external scintillating detectors. Pipeline tool 100 can also be fitted with backup pigging disks, to enable it to be pigged out of the pipeline, by a propelled chaser pig if so desired.

[0073] In this embodiment of the invention the central processing unit 132 is further provided with a mechanism by which it can calculate the distance travelled from the number of longitudinal piston strokes of the axial hydraulic ram system A or B.

[0074] The pipeline tool 100 is made from suitable light-weight material which gives the tool high strength to weight ratios, examples of such light-weight material include titanium 6Al 4V or carbon fibre, however any suitable material known to a person skilled in the art can be used.

[0075] It will of course be understood that the invention is not limited to the specific details described herein which are given by way of example only and that various modifications and alterations are possible without departing from the scope of the invention as defined by the appended claim.

Claims

1. An autonomous pipeline tool (100) comprising;
a device having a first part and a second part, the first and second parts being separable from each other;
a hydraulic system (A, B) comprising at least one hydraulic piston (140, 150, 160) and means for operating the piston, the hydraulic system being operable to returnably separate the first and second part of the device; the hydraulic system having a plurality of pipeline engaging means (142) positioned along an exterior surface of the

device, the pipeline engaging means being operable by the hydraulic system to be engagable with the interior surface of the pipeline (172); and
a control unit (130), the control unit being in communication with the hydraulic system to control the movement of the pipeline engaging means and the first and second parts such that the autonomous pipeline tool is moveable within a pipeline, **characterised in that** the hydraulic system (A, B) comprises independently operable primary (A) and backup (B) hydraulic systems, wherein the longitudinal rams (160a) of each hydraulic system (A, B) are arranged such that they are parallel to each other, wherein the hydraulic ram of the backup hydraulic system (B) remains recessed when not in use, wherein the hydraulic ram of the backup hydraulic system (B) is slightly shorter than the hydraulic ram of the primary hydraulic system (A).

2. An autonomous pipeline tool (100) as claimed in Claim 1, wherein the hydraulic system (A, B) comprises a plurality of hydraulic pistons or rams, wherein at least one piston or ram is an axial piston (140, 150) or ram (140a, 150a) and at least one piston or ram is a longitudinal piston (160) or ram (160a),
preferably wherein the axial rams (140a, 150a) and longitudinal ram (160a) are arranged such that they are perpendicular to one another.

3. An autonomous pipeline tool (100) as claimed in Claim 1 or Claim 2, wherein each hydraulic system (A, B) comprises at least nine rams wherein at least eight rams are axial rams (140a, 150a) and at least one ram is a longitudinal ram (160a).

4. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein each of the axial hydraulic rams (140a, 150a) is provided with a pipeline engaging means (142), optionally wherein each of the axial hydraulic rams are arranged such that standard opposing forces principles enable each of the pipeline engaging means (142) to engage with the internal surface of the pipeline wall such that the autonomous pipeline tool remains in position within the pipeline (172).

5. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the pipeline engaging means (142) is a coated compression pad, preferably wherein the coated compression pad is either a rubber coated compression pad or a threaded compression pad.

6. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the autonomous pipeline tool further comprises a plurality of wheels (120) at opposing ends of the autonomous pipeline tool (100) in a circular arrangement.

7. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the control unit (130) of the autonomous pipeline tool is provided as a control pod, which comprises at least one microprocessor, preferably wherein the control unit comprises at least two microprocessors.

8. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the control unit (130) is programmed with an embedded software program; and/or wherein the control unit (130) comprises a communications module, preferably a communications module which enables the autonomous pipeline tool to utilize ELF communications.

9. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the hydraulic system (A, B) comprises at least one hydraulic piston (240A, 244A) or ram coupled to a plurality of fluid pipes (220A) and hydraulic fluid which flows around the hydraulic circuit to effect movement of the autonomous pipeline tool.

10. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the control system of the autonomous pipeline tool comprises means for monitoring the operation of the hydraulic system,
preferably wherein means for monitoring the operation of the hydraulic system comprises one or more various types of sensors (232, 234, 236, 238) such as pressure sensors;
and/or wherein the means for monitoring the operation of the hydraulic system are provided with transmitters and receivers to enable transmission and receipt of information to and from a central processing unit (132) of the control system.

11. An autonomous pipeline tool (100) as claimed in Claim 10,
wherein a central processing unit (132) is programmed to detect whether or not the pressure levels detected by the means for monitoring the operation of the hydraulic system fall within predetermined parameters and whereby the

central processing unit is able to switch to the backup hydraulic system (B) in the event that the primary hydraulic unit (A) fails and the pressure levels fall outside predetermined parameters programmed into the central processing unit.

12. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the means for operating the hydraulic system of the autonomous pipeline tool comprises a pump (200A) for operating the rams and/or pistons, means for operating the pump (203A, 204A) and a plurality of fluid pipelines (220A) positioned between the pump and the hydraulic rams,
optionally wherein the hydraulic system (A, B) comprises an accumulator (202A) positioned in parallel with the pump.

13. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the hydraulic system (A, B) of the autonomous pipeline tool is provided with one or more check valves (216A) and/or controllers (210A, 212A, 214A) which control the flow of hydraulic fluid around the hydraulic circuit (242A) to control the movement of the pipeline engaging means (142) and the first and second parts of the autonomous pipeline tool such that the autonomous pipeline tool propels , in a controlled manner, a pipeline isolation tool along the inside of a pipeline,
optionally wherein the check valves of the hydraulic system are arranged in such a way to achieve a triple redundancy fail safe unset system.

14. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the autonomous pipeline tool comprises a sleep mode which is operable when the propulsion means are not in use.

15. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the autonomous pipeline tool is movable to a location by deploying the autonomous pipeline tool from a launcher barrel.

16. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the autonomous pipeline tool comprises a coupling mechanism (170) for connecting one or more further pipeline tools (174) or other technical equipment to the autonomous pipeline tool,
optionally wherein the coupling mechanism comprises one or more selected from the group comprising a double articulating ball and socket joint, a flexing spring joint, or a double acting universal joint.

17. An autonomous pipeline tool (100) as claimed in any one of the preceding claims, wherein the autonomous pipeline tool is coupled to a wheeled isolation tool comprising:

a housing having gripping and sealing members encircling the housing in communication with a hydraulic system;
a control unit in communication with one or more sensors and an actuator positioned within the housing;
the gripping and sealing members being movable between an unset position in which the gripping and sealing members are in an unexpanded configuration and a set position in which the gripping and sealing members are in an expanded configuration whereby the control unit operates an actuator to move an hydraulic piston within the hydraulic system such that the gripping and sealing members are moved between an unset position and a set position.

Patentansprüche

1. Autonomes Rohrleitungswerkzeug (100), aufweisend

eine Vorrichtung mit
einem ersten Teil und einem zweiten Teil, wobei das erste und zweite Teil voneinander trennbar sind,
ein Hydrauliksystem (A, B), aufweisend mindestens einen Hydraulikkolben (140, 150, 160) und Mittel zum Betreiben des Kolbens, wobei das Hydrauliksystem betreibbar ist, um das erste und zweite Teil der Vorrichtung rückführbar zu trennen, wobei des Hydrauliksystem eine Vielzahl von entlang einer Außenoberfläche der Vorrichtung positionierte Rohrleitungseingliffsmittel (142) hat, wobei die Rohrleitungseinguffsmittel durch das Hydrauliksystem betreibbar sind, um mit der Innenoberfläche der Rohrleitung (172) in Eingriff bringbar zu sein, und eine Steuereinheit (130), wobei die Steuereinheit in Verbindung mit dem Hydrauliksystem ist, um die Bewegung der Rohrleitungseingriffsmittel und der ersten und zweiten Teile derart zu steuern, dass das autonome Rohrleitungswerkzeug innerhalb einer Rohrleitung bewegbar ist, **dadurch gekennzeichnet, dass**
das Hydrauliksystem (A, B) unabhängig betreibbare Primär- (A) und Backup- (B) Hydrauliksysteme aufweist, wobei die Längsstößel (160a) von jedem Hydrauliksystem (A, B) derart angeordnet sind, dass sie parallel

zueinander sind, wobei der Hydraulikstößel des Backup-Hydrauliksystems (B) versenkt bleibt, wenn er nicht verwendet wird, wobei der Hydraulikstößel des Backup-Hydrauliksystems (B) geringfügig kürzer ist als der Hydraulikstößel des Primär-Hydrauliksystems (A).

2. Autonomes Rohrleitungswerkzeug (100) nach Anspruch 1, wobei das Hydrauliksystem (A, B) eine Vielzahl von Hydraulikkolben oder -stößel aufweist, wobei mindestens ein Kolben oder Stößel ein axialer Kolben (140, 150) oder Stößel (140a, 150a) ist und mindestens ein Kolben oder Stößel Längskolben (160) oder -stößel (160a) ist,

vorzugsweise wobei die axialen Stößel (140a, 150a) und Längsstößel (160a) derart angeordnet sind, dass sie senkrecht zueinander stehen.

3. Autonomes Rohrleitungswerkzeug (100) nach Anspruch 1 oder Anspruch 2, wobei jedes Hydrauliksystem (A, B) mindestens neun Stößel aufweist, wobei mindestens acht Stößel axiale Stößel (140a, 150a) sind und mindestens ein Stößel ein Längsstößel (160a) ist.

4. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei jedes der axialen Hydraulikstößel (140a, 150a) mit einem Rohrleitungseingriffsmittel (142) versehen ist, optional wobei jeder der axialen Hydraulikstößel derart angeordnet ist, dass Standardprinzipien entgegengesetzter Kräfte jeden der Rohrleitungseinguffsmittel (142) in die Lage versetzen, mit der internen Oberfläche der Rohrleitungswand derart einzugreifen, dass das autonome Rohrleitungswerkzeug innerhalb der Rohrleitung (172) in Position verbleibt.

5. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das Rohrleitungseinguffsmittel (142) ein beschichtetes Kompressionskissen ist, vorzugsweise wobei das beschichtete Kompressionskissen entweder ein gummibeschichtetes Kompressionskissen oder ein mit Gewinde versehenes Kompressionskissen ist.

6. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das autonomes Rohrleitungswerkzeug ferner eine Vielzahl vom Rädern (120) an gegenüberliegenden Enden des autonomen Rohrleitungswerkzeugs (100) in einer kreisförmigen Anordnung aufweist.

7. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei die Steuerungseinheit (130) des autonomen Rohrleitungswerkzeugs als eine Steuerungszelle vorgesehen ist, die mindestens einen Mikroprozessor aufweist, vorzugsweise wobei die Steuerungseinheit mindestens zwei Mikroprozessoren aufweist.

8. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei die Steuerungseinheit (130) mit einem eingebetteten Softwareprogramm programmiert ist und/oder wobei die Steuerungseinheit (130) ein Kommunikationsmodul, vorzugsweise ein Kommunikationsmodul, dass das autonome Rohrleitungswerkzeug in die Lager versetzt, ELF-Kommunikationen zu verwenden, aufweist.

9. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das Hydrauliksystem (A, B) mindestens einen an eine Vielzahl von Fluidrohren (220A) gekoppelten Hydraulikkolben (240A, 244A) oder -stößel und und Hydraulikfluid, das im Hydraulikkreislauf fließt, um die Bewegung des autonomen Rohrleitungswerkzeugs zu bewirken, aufweist.

10. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das Steuerungssystem des autonomen Rohrleitungswerkzeugs Mittel zur Überwachung des Betriebes des Hydrauliksystems aufweist, vorzugsweise wobei das Mittel zur Überwachung des Betriebes des Hydrauliksystems eine oder mehrere Typen von Sensoren (232, 234, 236, 238), wie Drucksensoren, aufweist
und/oder wobei die Mittel zur Überwachung des Betriebes des Hydrauliksystems mit Sendern und Empfängern versehen sind, um das Senden und Empfangen von Information an eine und von einer Zentraleinheit (132) des Steuerungssystems zu ermöglichen.

11. Autonomes Rohrleitungswerkzeug (100) nach Anspruch 10,
wobei eine Zentraleinheit (132) programmiert ist, um zu erkennen, ob die durch die Mittel zur Überwachung des Betriebes des Hydrauliksystems erkannten Druckniveaus innerhalb vorbestimmter Parameter fallen oder nicht und demzufolge die Zentraleinheit in der Lage ist, auf das Backup-Hydrauliksystem (B) im Fall, dass die Primär-Hydraulikeinheit (A) versagt und die Druckniveaus außerhalb vorbestimmter, in die Zentraleinheit einprogrammierter Parameter fallen, umzuschalten.

12. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das Mittel zum Betreiben des Hydrauliksystems des autonomen Rohrleitungswerkzeugs eine Pumpe (200A) zum Betreiben der Stößel und/oder Kolben, Mittel zum Betreiben der Pumpe (203A, 204A) und eine Vielzahl von zwischen der Pumpe und den Hydraulikstößeln positionierten Fluid-Rohrleitungen (220A) aufweist,

optional wobei das Hydrauliksystem (A, B) einen parallel zur Pumpe positionierten Speicher (202A) aufweist.

13. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das Hydrauliksystem (A, B) des autonomen Rohrleitungswerkzeug versehen ist mit einem oder mehreren Rückschlagventilen (216A) und/oder Steuergeräten (210A, 212A, 214A), die den Fluss des Hydraulikfluids im Hydraulikkreislauf (242A) steuern, um die Bewegung des Rohrleitungseingliffsmittels (142) und der ersten und zweiten Teile des

autonomen Rohrleitungswerkzeugs derart zu steuern, dass das autonome Rohrleitungswerkzeug in einer gesteuerten Art und Weise ein Rohrleitungsisolierungswerkzeug entlang dem Innern einer Rohrleitung vorwärts treibt,
optional wobei die Rückschlagventile des Hydrauliksystem so angeordnet sind, dass ein ausfallsicheres aufgehobenes System mit dreifacher Redundanz erreicht wird.

14. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das autonome Rohrleitungswerkzeug ein Schlafmodus aufweist, das betreibbar ist, wenn die Antriebsmittel nicht benutzt werden.

15. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das autonome Rohrleitungswerkzeug durch Entfalten des autonomen Rohrleitungswerkzeugs aus einem Startzylinder zu einer Position bewegbar ist.

16. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das autonome Rohrleitungswerkzeug einen Kopplungsmechanismus (170) zum Anschließen von einem oder mehreren weiteren Rohrleitungswerkzeugen (174) oder anderem technischen Gerät an das autonome Rohrleitungswerkzeug aufweist,

optional wobei der Kopplungsmechanismus einen oder mehrere aus der aus einem doppelt gelenkigen Kugelgelenk, einem Biegefedergelenk oder einem doppelt wirkendem Kreuzgelenk bestehenden Gruppe ausgewählten ausweist.

17. Autonomes Rohrleitungswerkzeug (100) nach einem der vorhergehenden Ansprüche, wobei das autonome Rohrleitungswerkzeug an ein mit Rädern versehenes Isolierungswerkzeug gekoppelt ist, das Folgendes aufweist:

ein Gehäuse mit Greif- und Dichtungselementen, die das Gehäuse in Verbindung mit einem Hydrauliksystem umgeben,
eine Steuerungseinheit in Verbindung mit einem oder mehreren Sensoren und einem innerhalb des Gehäuses positionierten Stellantrieb,
wobei die Greif- und Dichtungselemente zwischen einer aufgehobenen Position, in der die Greif- und Dichtungselemente in einer nicht-expandierten Ausgestaltung sind, und einer eingestellten Position, in der die Greif- und Dichtungselemente in einer expandierten Ausgestaltung sind, wodurch die Steuerungseinheit einen Stellantrieb betreibt, um einen Hydraulikkolben innerhalb des Hydrauliksystems derart zu bewegen, dass die Greif- und Dichtungselemente zwischen einer aufgehobenen Position und einer eingestellten Position bewegt werden.

Revendications

1. Outil autonome pour pipeline (100), comprenant :

un dispositif comprenant
un premier composant et un deuxième composant, les premier et deuxième composants pouvant être séparés l'un de l'autre ;
un système hydraulique (A,B) comprenant au moins un piston hydraulique (140, 150, 160) et un dispositif d'actionnement du piston, le système hydraulique pouvant être actionné pour séparer de façon réversible les premier et le deuxième composants du dispositif ; le système hydraulique possédant une pluralité de dispositifs d'engagement de pipeline (142) positionnés le long d'une surface extérieure du dispositif, les dispositifs d'en-

gagement de pipeline étant actionnables par le système hydraulique pour s'engager avec la surface intérieure du pipeline (172) ; et une unité de commande (130), l'unité de commande étant en communication avec le système hydraulique pour commander les déplacements des dispositifs d'engagement de pipeline ainsi que les premier et le deuxième composants, de sorte que l'outil autonome pour pipeline puisse se déplacer au sein d'un pipeline, **caractérisé en ce que**
le système hydraulique (A, B) comprend des systèmes hydrauliques principal (A) et de réserve (B) actionnables indépendamment, les vérins longitudinaux (160a) de chaque système hydraulique (A, B) étant agencés de façon à ce qu'ils soient parallèles entre eux, le vérin hydraulique du système hydraulique de réserve (B) restant encastré lorsqu'il n'est pas utilisé, le vérin hydraulique du système hydraulique de réserve (B) étant légèrement plus court que le vérin hydraulique du système hysdraulique principal (A).

2. Outil autonome pour pipeline (100) selon la revendication 1, le système hydraulique (A, B) comprenant une pluralité de pistons ou vérins hydrauliques, au moins un piston ou vérin étant un piston axial (140, 150) ou un vérin axial (140a, 150a), et au moins un piston ou vérin étant un piston longitudinal (160) ou vérin longitudinal (160a),
de préférence les vérins axiaux (140a, 150a) et le vérin longitudinal (160a) étant agencés de sorte qu'ils soient perpendiculaires entre eux.

3. Outil autonome pour pipeline (100) selon la revendication 1 ou la revendication 2, chaque système hydraulique (A, B) comprenant au moins neuf vérins, au moins huit desquels sont des vérins axiaux (140a, 150a), et au moins un desquels est un vérin longitudinal (160a).

4. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, chacun des vérins hydrauliques axiaux (140a, 150a) étant muni d'un dispositif d'engagement de pipeline (142), en option chacun des vérins hydrauliques axiaux étant disposé de sorte que des principes de forces opposées standards permettent à chaque dispositif d'engagement de pipeline (142) à venir en prise avec la surface interne de la paroi du pipeline, de sorte que l'outil de pipeline autonome reste en place au sein du pipeline (172).

5. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, le dispositif d'engagement de pipeline (142) étant un tampon de compression enrobé, de préférence le tampon de compression enrobé étant soit un tampon de compression revêtu de caoutchouc, soit un tampon de compression fileté.

6. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'outil autonome pour pipeline comprenant une pluralité de roues (120) aux extrémités opposées de l'outil autonome pour pipeline (100), dans un agencement circulaire.

7. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'unité de commande (130) de l'outil autonome pour pipeline se présentant comme un commodo comprenant au moins un microprocesseur, de préférence l'unité de commande comprenant au moins deux microprocesseurs.

8. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'unité de commande (130) étant programmée avec un logiciel intégré et/ou l'unité de commande (130) comprenant un module de communications, de préférence un module de communications permettant à l'outil autonome pour pipeline d'utiliser des communications ELF.

9. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, le système hydraulique (A, B) comprenant au moins un piston hydraulique (240A, 244A) ou un vérin accouplé avec une pluralité de tuyaux de fluide (220A) et de fluide hydraulique s'écoulant autour du circuit hydraulique pour effectuer un mouvement de l'outil autonome pour pipeline.

10. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, le système de commande de l'outil autonome pour pipeline comprenant un dispositif de contrôle du fonctionnement du système hydraulique, de préférence le dispositif de contrôle du fonctionnement du système hydraulique comprenant un ou plusieurs types de capteurs (232, 234, 236, 238), par exemple des capteurs de pression ;

et/ou le dispositif de contrôle du fonctionnement du système hydraulique étant muni de transmetteurs et récepteurs pour permettre la transmission d'informations à un processeur central (132) du système de contrôle et la réception d'informations de ce dernier.

11. Outil autonome pour pipeline (100) selon la revendication 10,

un processeur central (132) étant programmé pour détecter si les niveaux de pression détectés par le dispositif contrôle du fonctionnement du système hydraulique sont compris, ou non, dans des paramètres prédéterminés, et si le processeur central est en mesure de passer au système hydraulique de réserve (B) en cas de défaillance du système hydraulique principal (A) et les niveaux de pression ne sont plus compris dans des paramètres prédéterminés programmés dans le processeur central.

12. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, le dispositif d'utilisation du système hydraulique de l'outil autonome pour pipeline comprenant une pompe (200A) pour l'actionnement des vérins et/ou des pistons, un dispositif pour l'utilisation de la pompe (203A, 204A), et une pluralité de pipelines de fluides (220A) positionnés entre la pompe et les vérins hydrauliques,

en option le système hydraulique (A, B) comprenant un accumulateur (202A) positionné parallèlement à la pompe.

13. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, le système hydraulique (A, B) de l'outil autonome pour pipeline étant muni d'un ou plusieurs clapets (216A) et/ou régulateurs (210A, 212A, 214A) assurant la régulation du fluide hydraulique autour du circuit hydraulique (242A) pour commander le mouvement du dispositif d'engagement de pipeline (142) et les premier et deuxième composants de l'outil autonome pour pipeline de façon à assurer la propulsion contrôlée, par l'outil autonome pour pipeline, d'un outil d'isolation de pipeline le long de l'intérieur d'un pipeline, en option les clapets du système hydraulique étant disposés de façon à former un système de désactivation à sécurité intrinsèque et triple redondance.

14. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'outil autonome pour pipeline comprenant un mode de veille pouvant être actionné lorsque le dispositif de propulsion n'est pas utilisé.

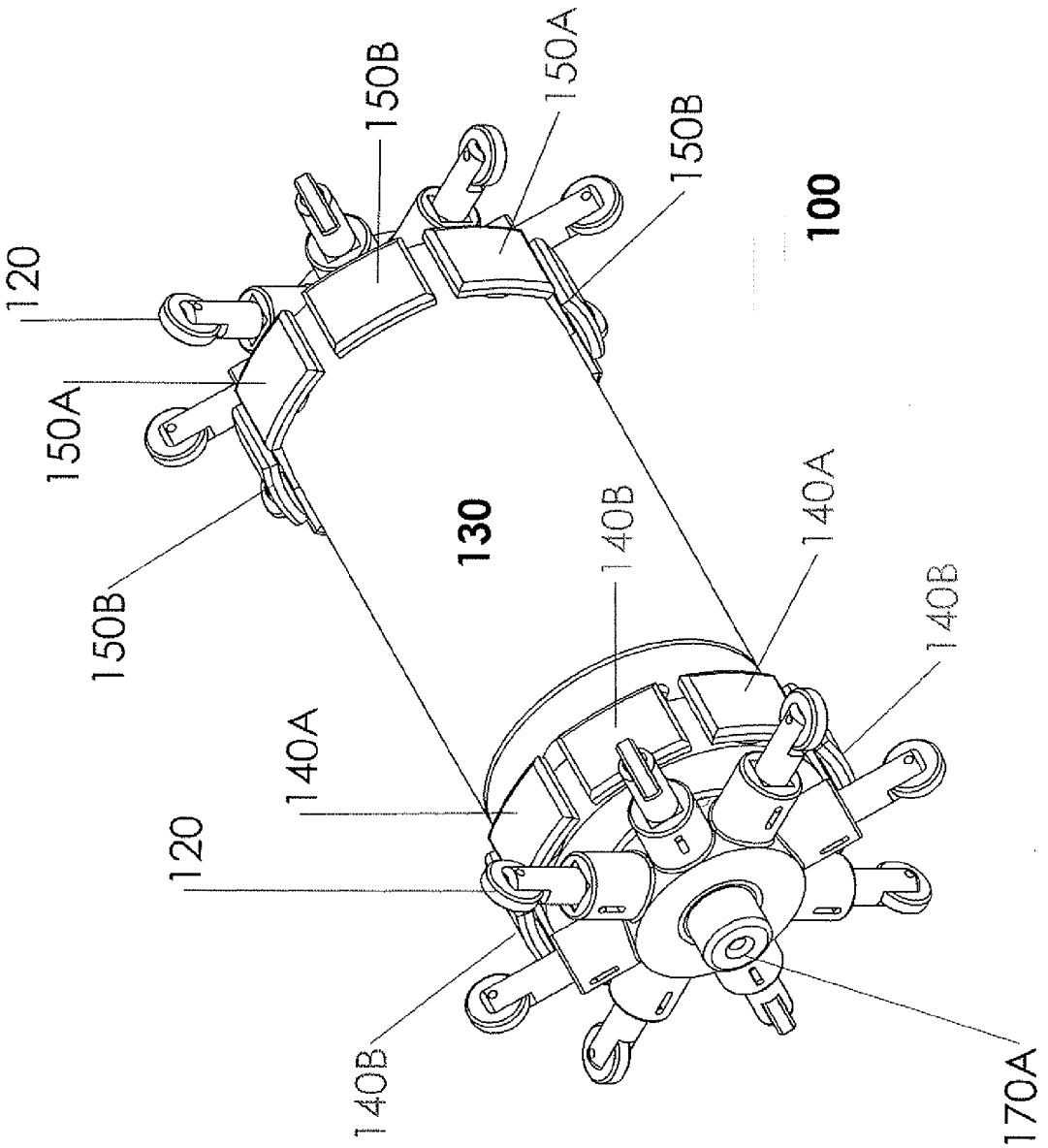
15. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'outil autonome pour pipeline pouvant être déplacé dans un emplacement en déployant l'outil autonome pour pipeline depuis un cylindre de lancement.

16. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'outil autonome pour pipeline comprenant un mécanisme d'accouplement (170) pour raccorder un ou plusieurs autres outils pour pipeline (174) ou autres équipements techniques sur l'outil autonome pour pipeline,

en option le mécanisme d'accouplement comprenant un ou plusieurs éléments parmi le groupe suivant : double articulation à rotule, articulation à ressort, ou joint universel à double action.

17. Outil autonome pour pipeline (100) selon une quelconque des revendications précédentes, l'outil autonome pour pipeline étant accouplé avec un outil d'isolation à roues comprenant :

un logement comprenant des éléments de préhension et d'étanchéité encerclant le logement en communication avec un système hydraulique ;
une unité de commande en communication avec un ou plusieurs capteurs et un actionneur positionné au sein du logement ;
les éléments de préhension et d'étanchéité pouvant être déplacés entre une position désactivée dans laquelle les éléments de préhension et d'étanchéité se trouvent dans une configuration non déployée, et une position activée dans laquelle les éléments de préhension et d'étanchéité se trouvent dans une configuration déployée, l'unité de commande actionnant un actionneur pour déplacer un piston hydraulique au sein du système hydraulique, afin que les éléments de préhension et d'étanchéité se déplacent entre une position désactivée et une position activée.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150B
150B
150A
100
130
140B
140A
140B
140A
120
140B
170A

Fig 1A

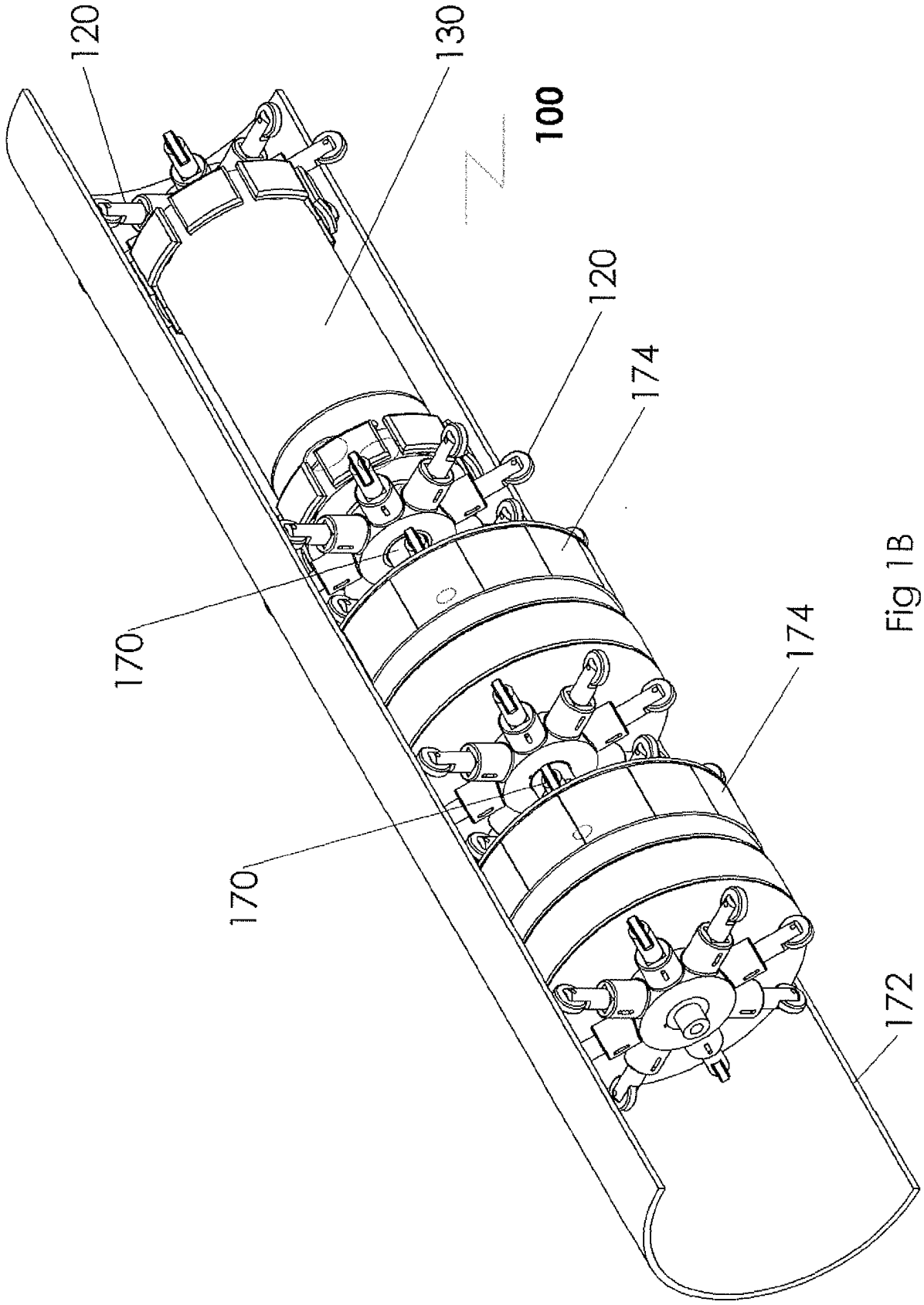


Fig 1B

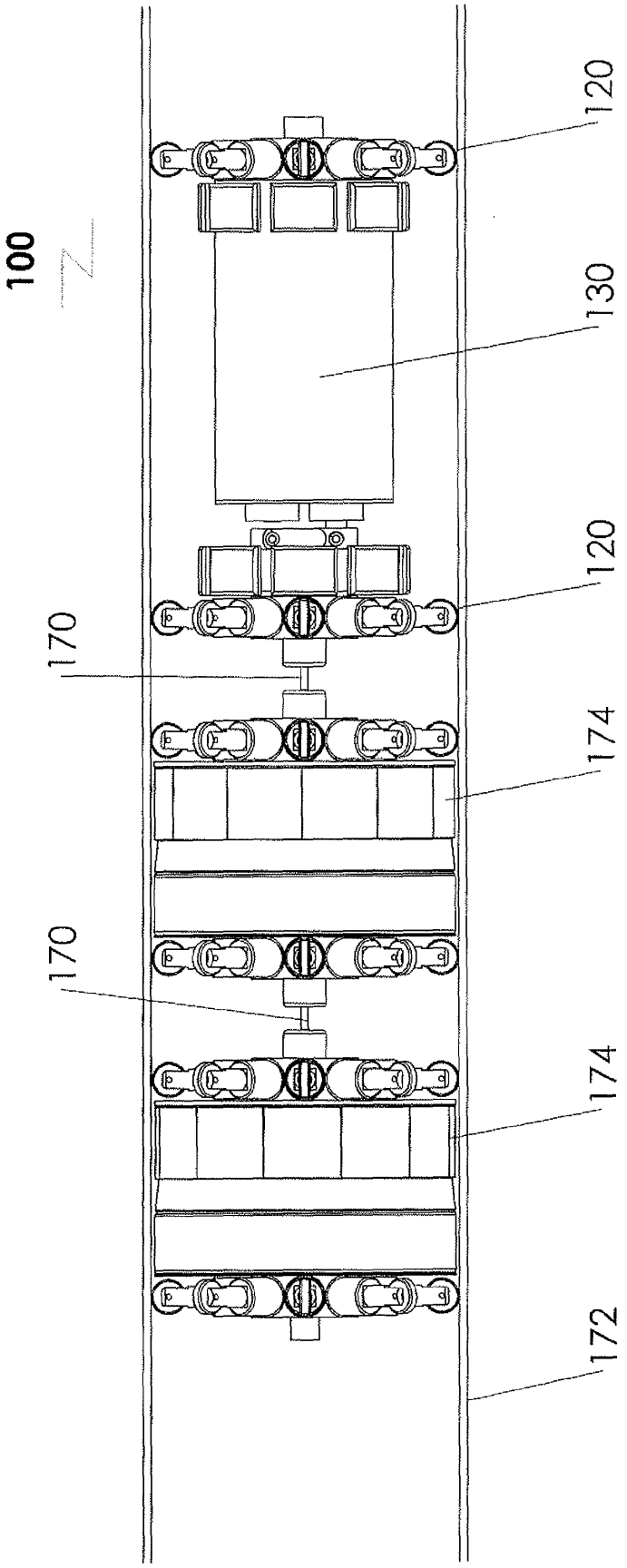
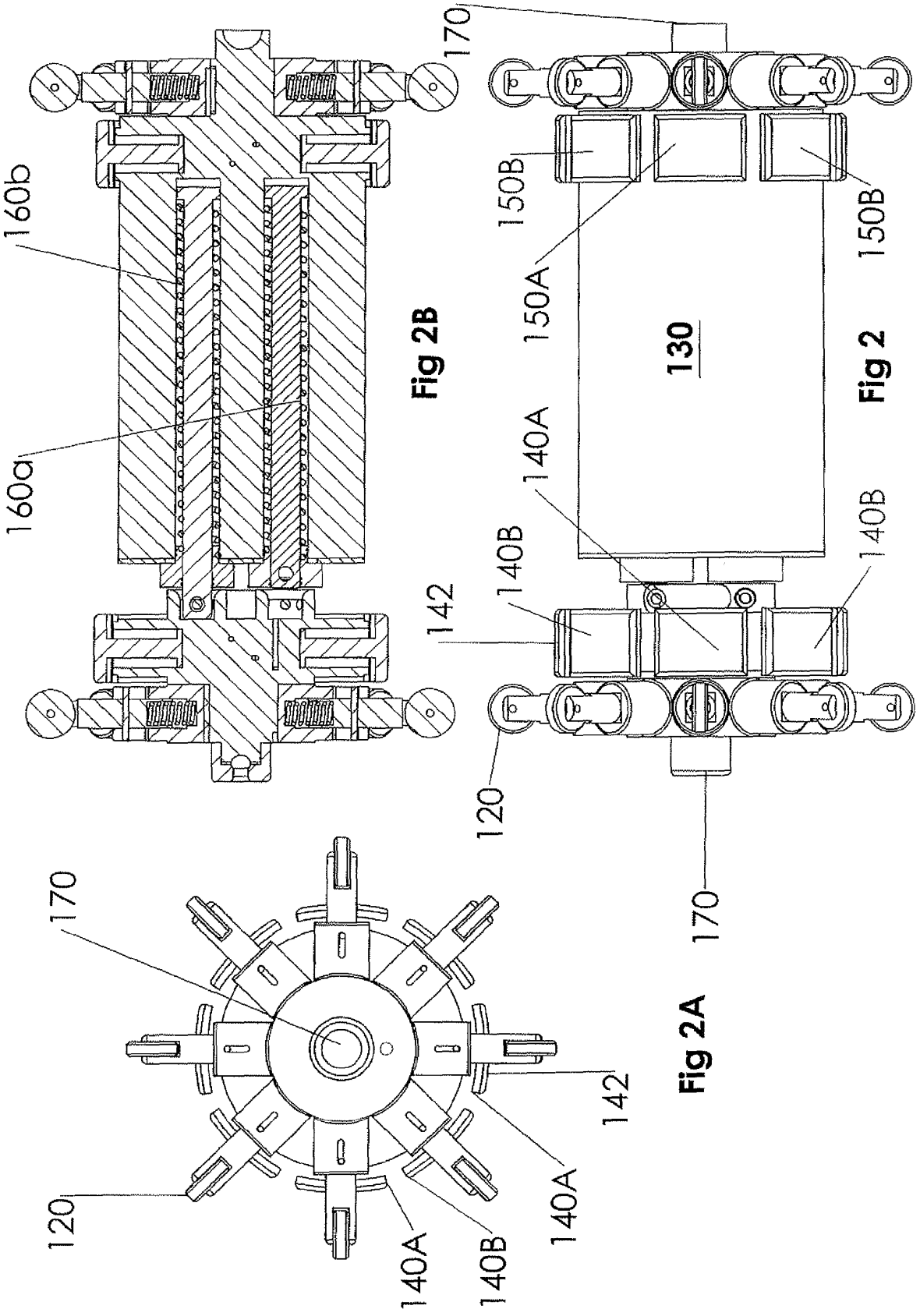


Fig 1C


160b
160a
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150B
150A
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140A
140B
142
120
170
Fig 2B
Fig 2
Fig 2A

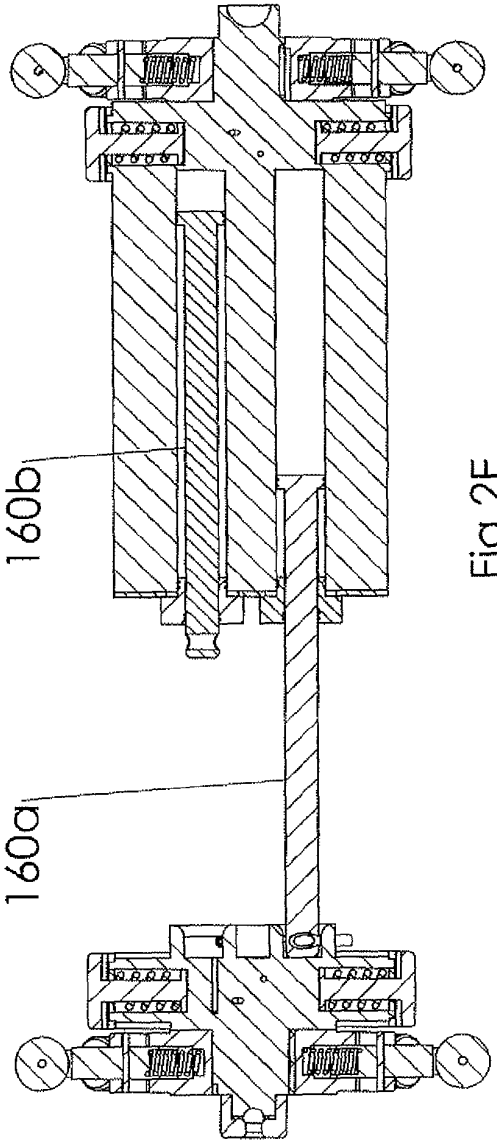


Fig 2E

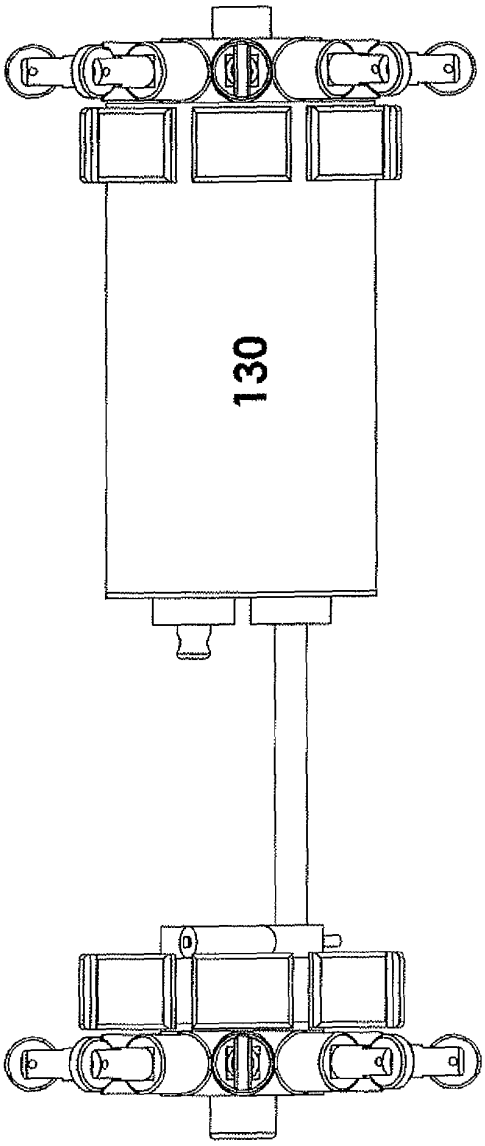


Fig 2D

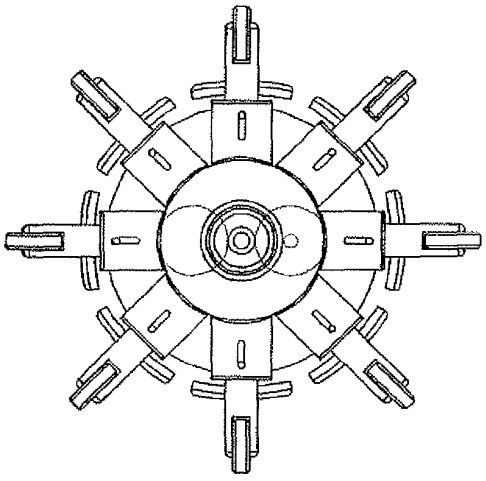


Fig 2C

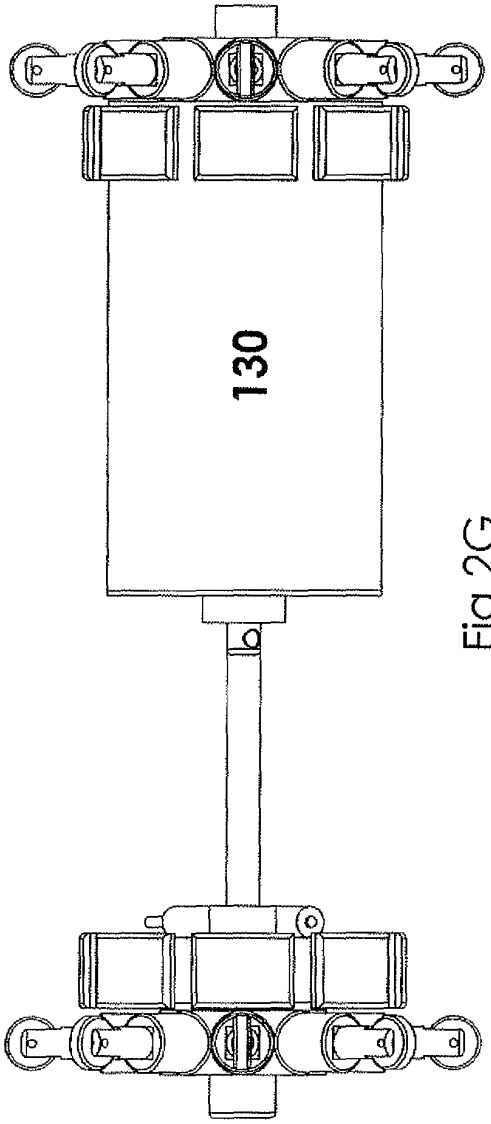


Fig 2G

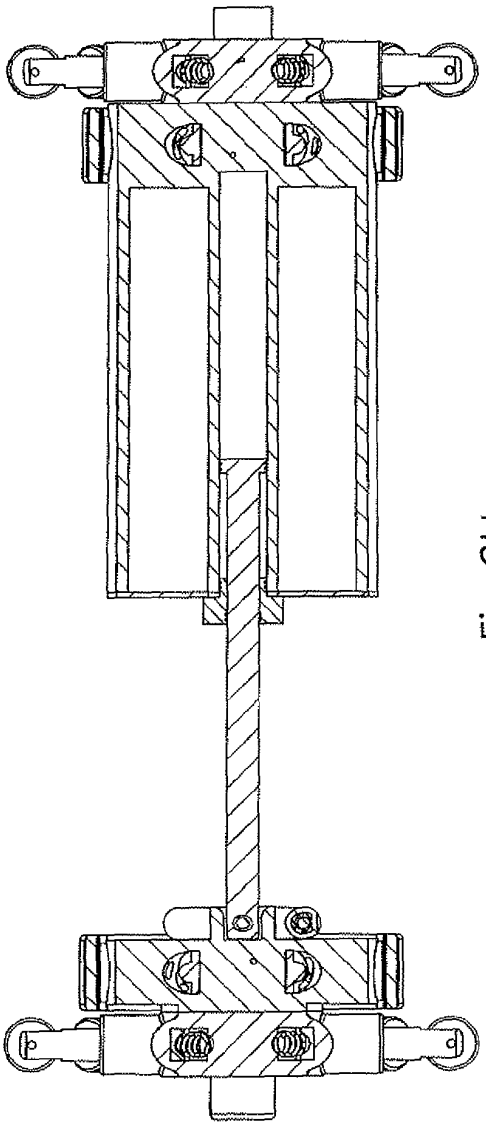
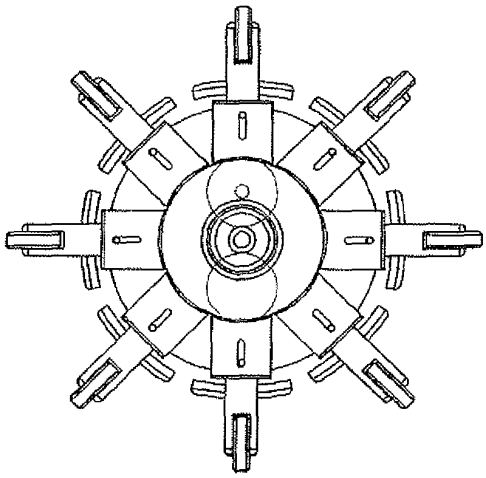


Fig 2H



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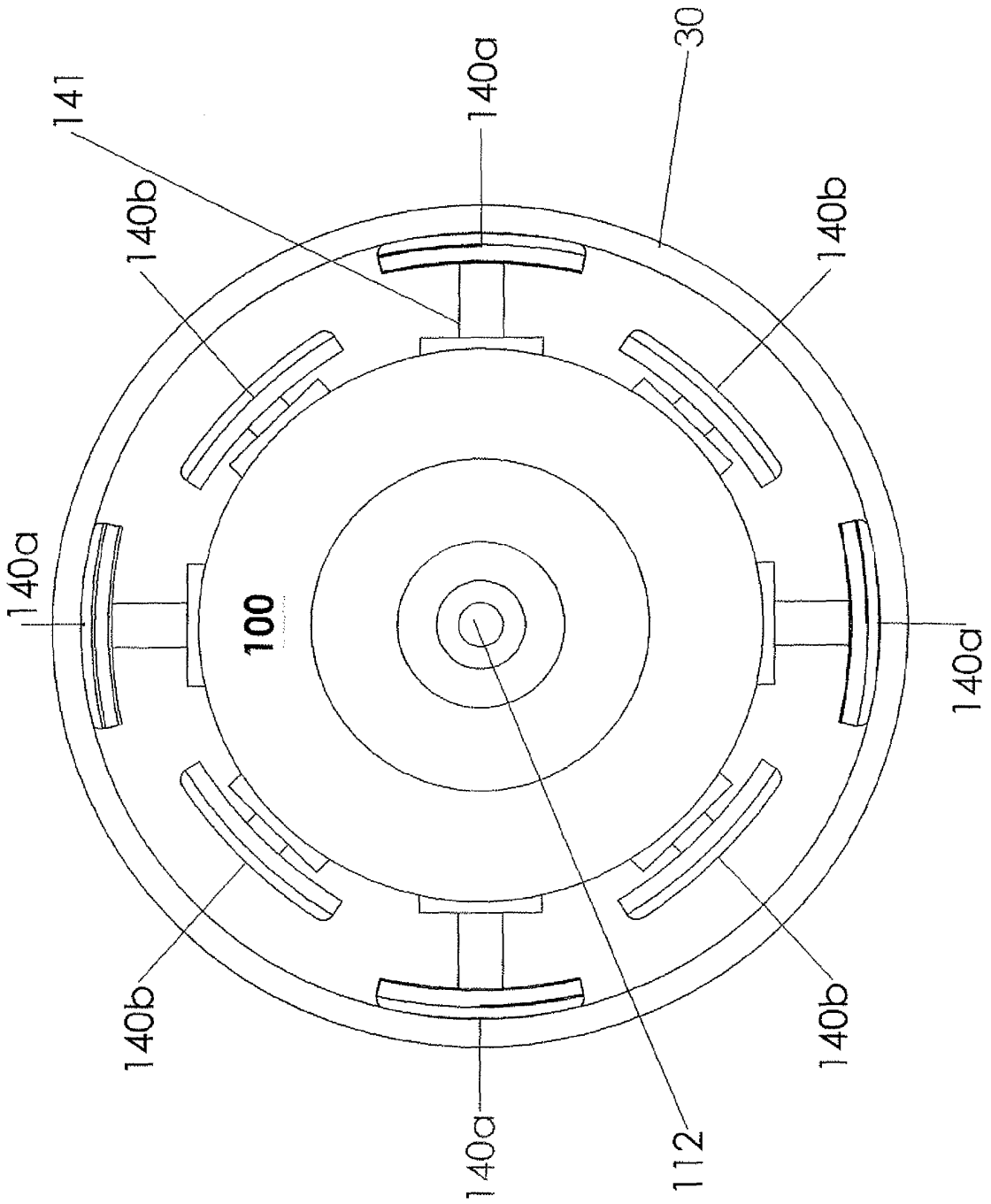


Figure 3

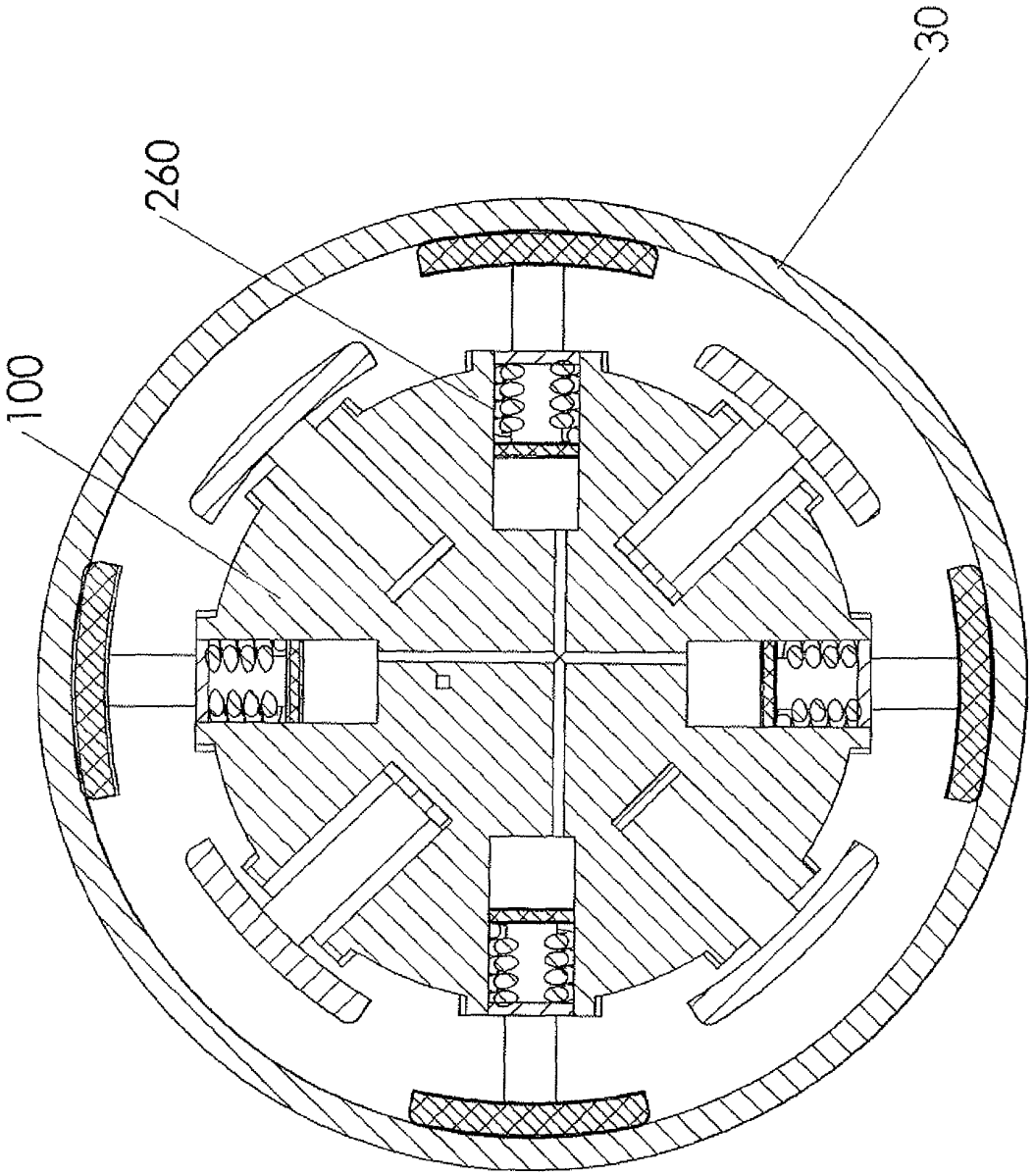


Figure 3A

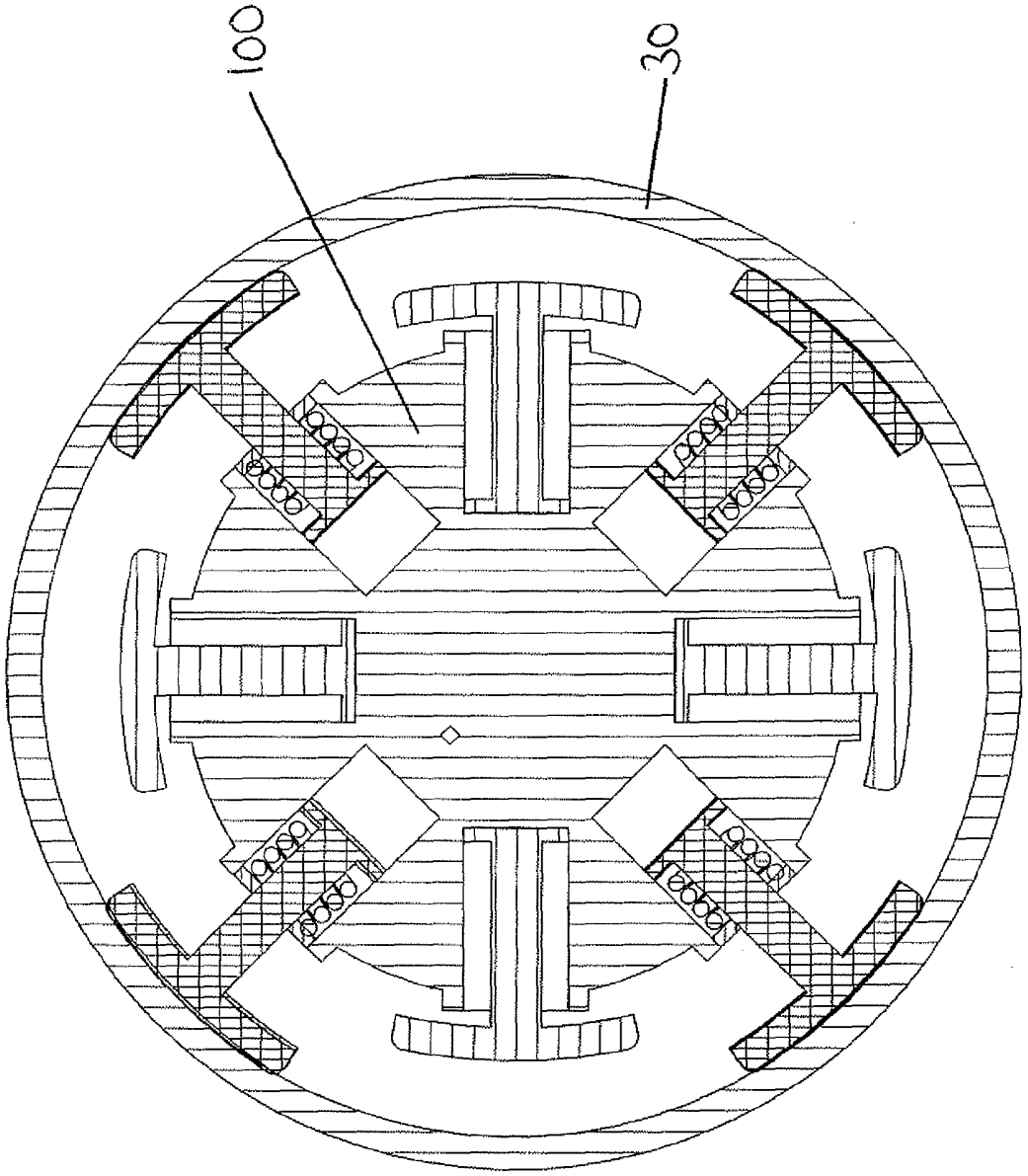


Figure 3B

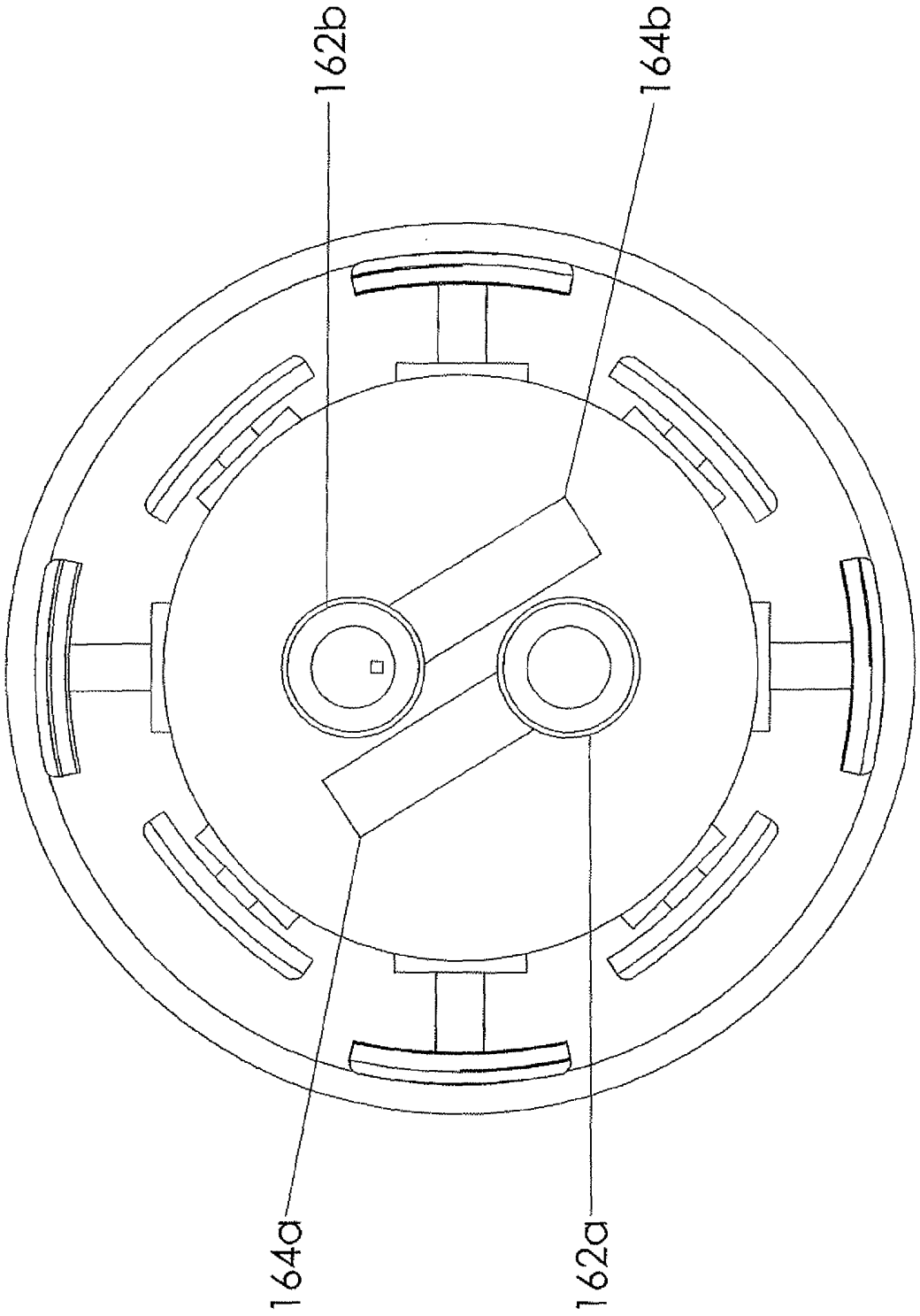


Figure 3C

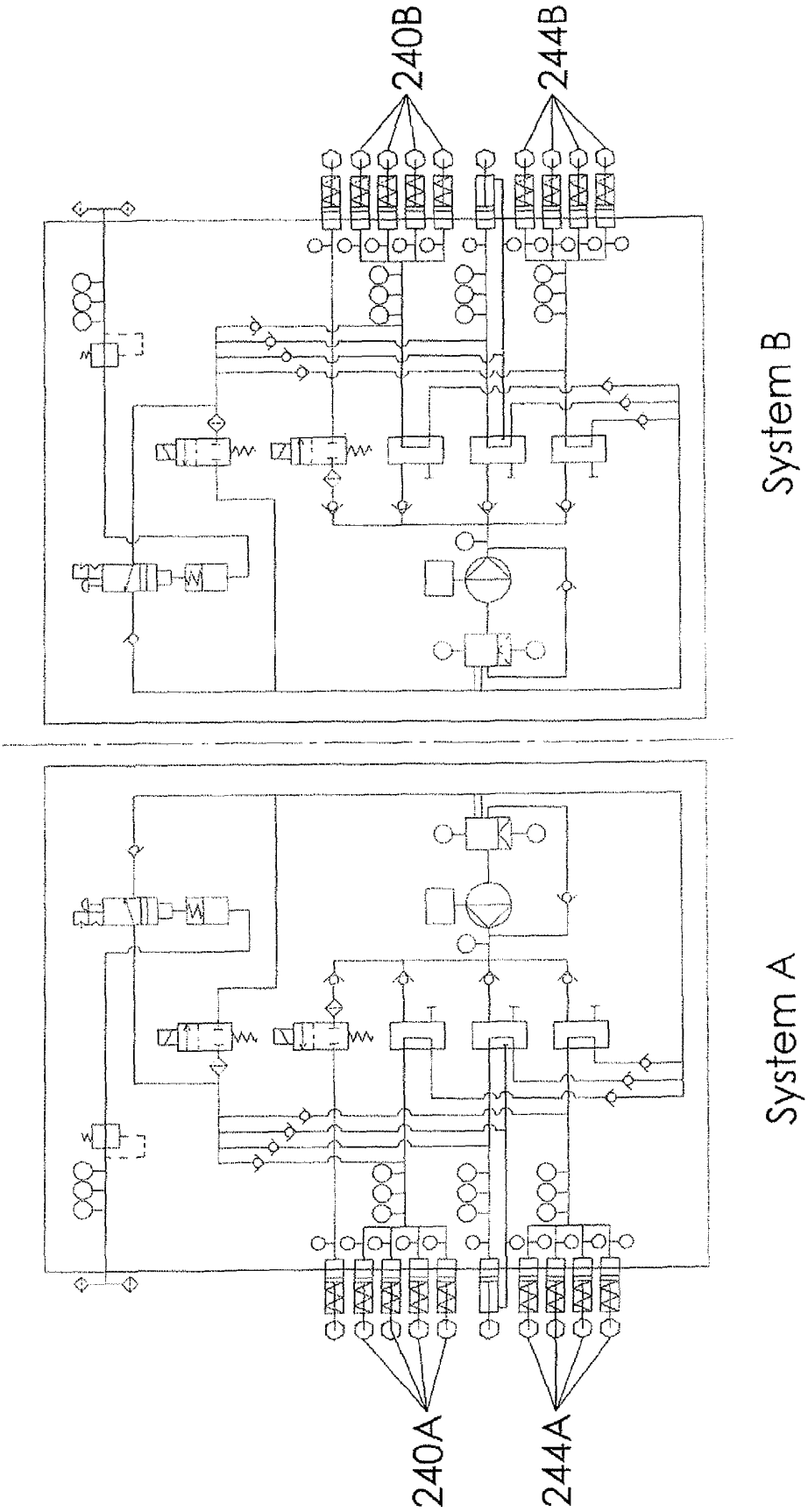
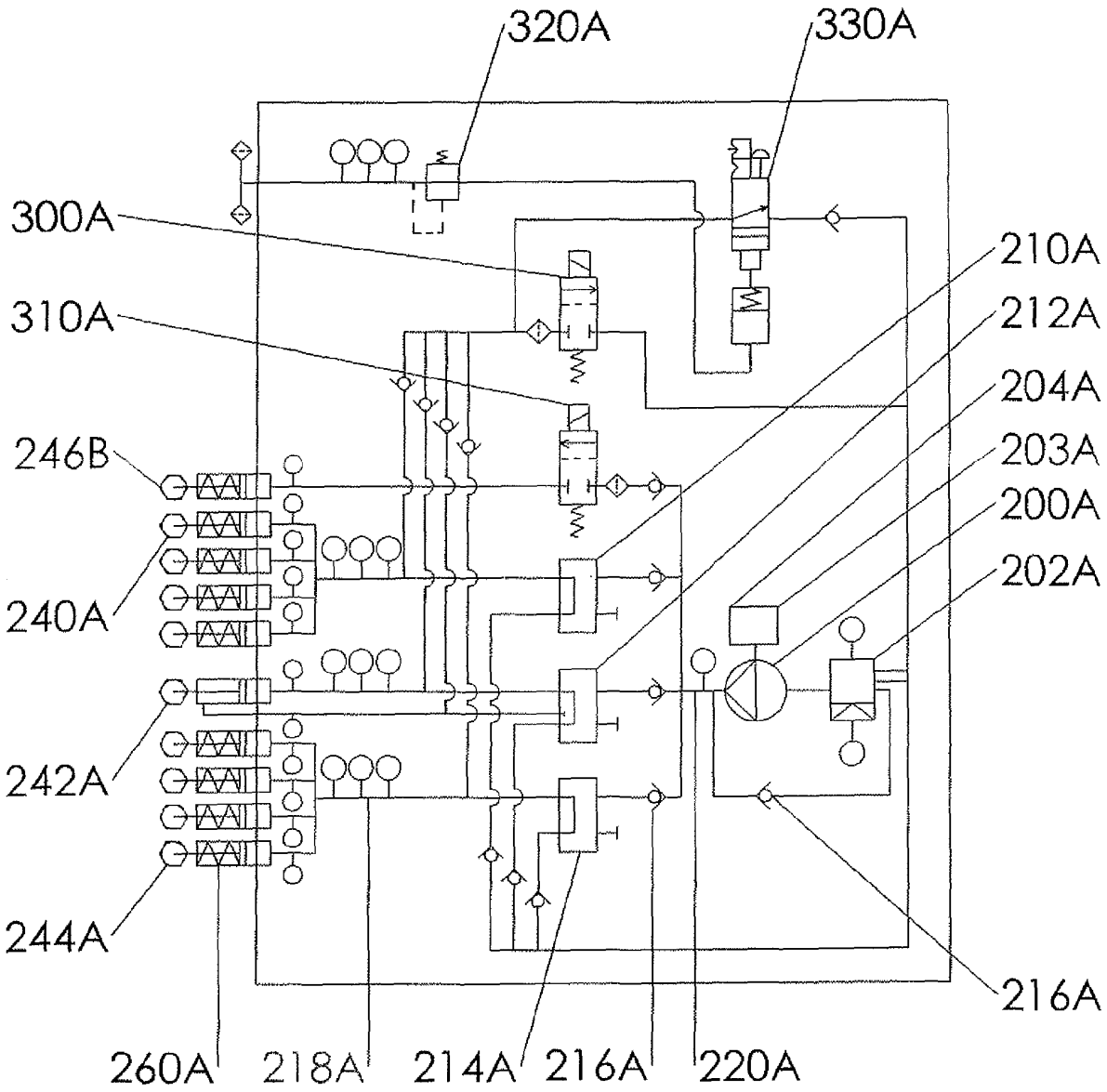


Fig 4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202A
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260A
218A
214A
216A
220A

Fig 4A

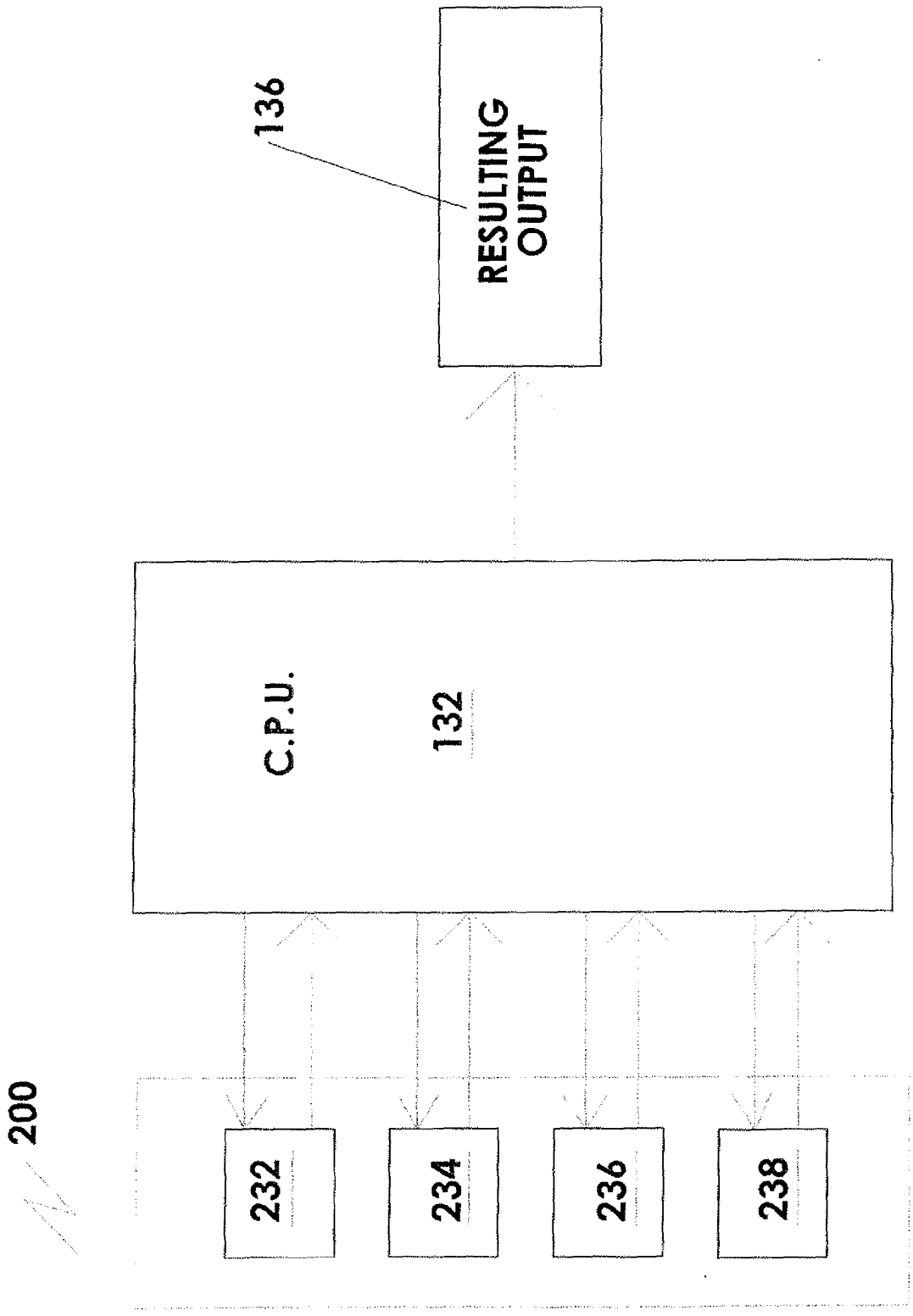

Fig 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2005061944 A **[0009]**